(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 356 050 B1**

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification : **26.08.92 Bulletin 92/35**

(51) Int. Cl.^{5} : **A61F 2/16**

(21) Application number : **89307952.5**

(22) Date of filing : **04.08.89**

(54) **Accommodating intraocular lens.**

(30) Priority : **15.08.88 US 232600**

(43) Date of publication of application : **28.02.90 Bulletin 90/09**

(45) Publication of the grant of the patent : **26.08.92 Bulletin 92/35**

(84) Designated Contracting States : **CH DE ES FR GB IT LI NL**

(56) References cited :
EP-A- 0 212 616
US-A- 4 253 199
US-A- 4 254 509

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Description

BACKGROUND AND SUMMARY OF THE INVENTION

The invention relates generally to intraocular lenses for the human eye and, more particularly, to intraocular lenses that change in refractive power (i.e. "accommodate") in response to eye muscle movement to focus on objects at different distances as viewed from the viewer.

Figures 1 through 4 illustrate the accommodation function of a normal, natural human eye, with Figure 1 showing a human eye in cross-section. The eye structure includes a cornea 13, an iris 16, a ciliary body 17, suspensory ligaments or zonules or zinn 18, a crystalline lens 19 surrounded by a capsular bag 20, and a retina 27. The ciliary body 17 includes muscle tissue, which controls the focal length of the lens 19. When individual circumferential muscle fibers 21 of the ciliary body 17 relax (i.e., when the dimensions 23 increase), the aperture diameter 25 within the ciliary body 17 increases, as shown in Figures 2A and 2B.

As shown in Figures 3A and 3B, this increase in aperture diameter puts tension on the zonules 18, which in turn stretch the crystalline lens 19, causing the lens 19 to assume elongated shape 19E. The elongated lens 19E has a refractive power suitable for focusing distant objects upon the retina 27. When it is necessary to focus nearby objects, the muscle fibers 21 of ciliary body 17 contract, decreasing the aperture diameter 25 shown in Figure 2A. In response to this contraction, the inherent elasticity of the lens 19 causes it to contract to the unstretched shape shown in Figure 3A. This ability of the human optical system to change the shape of the lens 19 (and thus the refractive power) in order to focus on either distant or nearby objects is called "accommodation".

The lens 19 of the human eye can, however, suffer disease, such as a cataract, in which case surgical removal of the lens 19 may be necessary. After removal, the natural lens 19 can be replaced by an articicial lens 32 shown in Figure 4, which is termed an intraocular lens (IOL). One type of IOL 32 is shown in Figure 5A and 5B. The lens 32 is supported by haptics 36, which rest generally at points 37 in Figure 4 after implantation in the eye.

The IOL 32 restores much of the visual acuity of the eye, but has the characteristic of properly focusing only images of objects 34 in Figure 4 which are within the depth of field 39 of the focusing system, said system being comprised of the IOL 32 and the cornea 13. Other objects, such as the object 41 located in the far field 43, are not in focus, and thus appear blurred. It is also possible, instead, for the focusing system to properly focus objects in the far field 43 but not in the near field 39. The accommodation necessary to selectively focus on both near and far objects, formerly provided by the crystalline lens 19, has thus been reduced of lost.

It is therefore highly desirable to restore accommodation in order to allow the patient with an IOL to selectively focus objects located at all distances. Thus, one of the primary objects of the present invention is to provide an intraocular lens which can focus objects located at different distance upon the retina, depending upon the relaxed or contracted state of the ciliary body muscles.

One form of the invention comprises a replacement lens for the human eye, which changes in focal length as the ciliary muscle contracts and relaxes.

The prior art portions of claims 1, 12 and 18 are respectively based upon US-A-4 253 199. This prior construction utilises a flexible lens, the shape of which is variable to change its focal length, depending upon the extent to which it is stretched by the operation of the ciliary muscles to which it is attached. The accommodating intracular lens apparatus according to the present invention includes a lens member having a flexible portion and a relatively rigid portion, with a chamber therbetween. The apparatus also includes an accommodation provision for changing the shape or position of the flexible lens member in response to muscle movement of the eye. Such accommodation feature provides the mechanism to change the refractive characteristics of the flexible lens member and thus allows the intraocular lens patient to focus on objects at varying distances in much the same way as did the patient's natural crystalline lens.

The present invention as defined in each of claims 1, 2, 12 and 18 utilises a fluid system to provide a degree of response to changes in the ciliary body to provide changes in focal length which is not so readily obtained with the simple transverse stretching construction of US-A-253 199. With the present invention, accommodation capability is provided by way of a hydraulic or other fluid system incorporated into the intraocular lens apparatus for selectively pressurising and de-pressurising a fluid-filled (liquid or gaseous) chamber defined by the flexible lens member and a relatively rigid supporting member in order to vary the refractive powers or characteristics of the overall lens system selectively.

While EP-A-0 212 616 discloses a lens, the characteristics of which can be changed by varying the pressure of fluid applied thereto, this is in conjunction with a fixed lens with externally controlled means being used to vary the position of the interface between two fluids within the lens and suggest no means by which the internal pressure of fluid in a lens and suggest no means by which the internal pressure of fluid in a lens can be changed in response to muscle movement of the eye in order to change its focal length as provided by the present invention.

Additional objects, advantages and features of the present invention will become apparent from the following description and appended claims, taken in conjunction with the accompanying drawings, in which:-

Figure 1 diagrammatically illustrates a human eye in cross-section.

Figure 2A and 2B diagrammatically illustrate dilation of the ciliary body of the eye.

Figure 3A and 3B diagrammatically illustrate how the dilation shown in Figure 2B stretches the crystalline lens and changes its focal length.

Figure 4 illustrates an intraocular lens that can be used to replace the natural lens 19 in Figure 1.

Figure 5A and 5B are enlarged views of a common type of intraocular lens.

Figure 6 illustrates an exploded view of an intraocular lens apparatus according to one form of the invention.

Figure 7 illustrates a detailed view of the intraocular lens apparatus of Figure 6 shown in cross-section.

Figures 8A and 8B illustrate the change in shape of the chamber of the lens apparatus shown in Figure 7, which occurs during use of the invention.

Figure 9 illustrates one form of the intraocular lens apparatus of the present invention.

Figure 10 illustrates another form of the intraocular lens apparatus of the present invention implanted within the ciliary body of the eye.

Figure 11 illustrates a preferred form of the present invention, including pressure sources used to inflate flexible bladders, which contact or expand in response to the ciliary body.

Figure 12 shows in schematic form how the ciliary body compresses one pair of the bladders shown in Figure 11.

Figure 13 shows the apparatus of Figure 11 in perspective, cut-away form.

Figure 14 is a view similar to that of Figure 10, but illustrating still another form of the intraocular lens apparatus of the present invention.

Figure 15 is a partial detail view of the lens apparatus of Figure 14, illustrating a hollow haptic member.

Figure 16 is a view similar to that of Figure 15, but illustrating how the ciliary body deforms the hollow haptic member to cause accommodation.

Figure 17 is a cross-sectional view taken generally along line 17-17 of Figure 15.

Figure 18 is a cross-sectional view similar to that of Figure 17, but illustrating an alternate haptic construction.

Figure 19 is a cross-sectional view similar to that of Figures 17 and 18, but illustrating still another alternate haptic construction.

Figure 20 is a view similar to that of Figures 10 and 14, but diagrammatically illustrates still another form of the present invention.

Figure 21 is a partial cross-section view taken generally along line 21-21 of Figure 20.

Figure 22 is a cross-sectional view taken generally along line 22-22 of Figure 20.

Figure 23 is a partial cross-sectional view similar to that of Figure 22, but illustrating an alternate construction.

Figure 24 is a partial detailed view of the apparatus of Figure 20, but illustrating an optional construction.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Figures 6 through 24 depict exemplary embodiments of the present invention for purposes of illustration. One skilled in the art will readily recognize from the following description and the accompanying drawings that the principles of the present invention are also applicable to intraocular lenses other than those depicted in the drawings.

Figure 6 illustrates one exemplary form of the invention, in which an IOL 48 is shown in cross-section in Figure 7. A thin, membrane-like lens 50 is sealed along its periphery 52 to a thicker support lens 54, which contains a circular recessed cavity 53, thereby forming a fluid-filled (liquid or gaseous) cavity or chamber 56 (shown in Figure 7) between the two lenses. Fluid pressure is applied to the chamber 56, by an apparatus discussed below, in order to drive the membrane-lens 50 into the shape or position 59 (shown in phantom lines in Figure 7). This change in position or shape changes the refractive powers or characteristics of the overall lens system 48, which includes the two lenses 50 and 54 and the fluid chamber 56.

The above-mentioned change in refractive characteristics is caused primarily by the change in shape of the chamber 56 from the shape shown in Figure 8A to that shown in Figure 8B. Since the chamber 56 is fluid-filled, as is discussed below, it too acts as a lens, and the altered shape shown in Figure 8B provides a refraction that is different from that of the former shape shown in Figure 8A. The fluid-filled chamber 56 thus effectively functions as a lens of a variable focal length, making the overall lens 48 have a variable focal length.

In one form of the invention, the IOL 48A of Figure 6 can be implanted using standard haptics 36, such as those shown in Figure 9, with the dashed circle 52 indicating the periphery of the membrane lens 50 in Figure 6. Alternately, a number of supporting bladders 70A are preferably used to lodge the IOL 48B within the capsular bag 20, as shown in Figures 10 through 13, and as described in more detail below. The supporting bladders 70A allow an IOL of fixed size, having a given diameter 67, such as that shown in

Figure 9, to be used in eyes having any of several diameters 25 of the capsular bag equator as shown in Figure 2. Thus the invention is adaptable to patients having capsular bags of different sizes.

As is shown diagrammatically in Figures 11 and 13, the supporting bladders 70A are all connected to a common manifold 75, called a support manifold, which distributes fluid pressure to the bladders 70A. During implantation in the eye, the fluid pressure is applied by a source, such as a syringe 77, through a line 79, which is then removed from a valve 81 when the proper pressure is attained. The bladders 70A are inflated and pressurized until they contact the ciliary body 17, as shown in Figure 10, at which time the external pressure source 77 is removed.

In either of the exemplary IOL's 48A or 48B, a number of bladders 70B shown in Figures 9 through 11, which are termed focusing or accommodation bladders, are all connected to a second, accommodation manifold 85, which is illustrated by a thicker line in order to distinguish it from the support manifold 75. In addition, the accommodation manifold 85 is in fluid communication with the fluid chamber 56, as indicated by fluid arrows 89. During implantation into the eye, the accommodation bladders 70B are inflated by an external pressure source 77 as described above, but to a lower final pressure than that of the support bladders 70A.

The membrane lens 50 in Figures 9 and 10 functions much like a wall of a pressure vessel, which is defined by the chamber 56 and which is in fluid communication with the accommodation manifold 85 and the accommodation bladders 70B. The membrane 50 is a flexible member in tension and supported only at its circular periphery 52, and thus can resist only small internal pressures within the chamber 56 without deformation. Since the flexible membrane 50 has a very low moment of inertia, it deforms into the position 59 in Figure 7 under a slight increase in fluid pressure.

When focusing, the eye deforms either the IOL of the present invention or the natural crystalline lens 19 in Figure 1 in similar ways. When the IOL 48A or 48B of the present invention is implanted, the ciliary body 17 contracts, and the focusing bladders 70B become compressed as shown in Figure 12. This compression forces fluid into the chamber 56 as indicated by fluid arrows 89 in Figure 11. The membrane lens 50 is thus slightly pressurized and deforms into the shape or position 59 shown in phantom lines in Figure 7 as the chamber 56 deforms into the shape indicated in Figure 8B. As discussed above, this deformation allows the lens system to focus nearly objects onto the retina.

Relaxation of the ciliary body 17 operates in reverse, allowing the membrane lens 50 to return to its former position shown in solid lines in Figure 7, and allowing the excess fluid to flow out of the chamber 56 back to the bladders 70B. Similarly, the chamber 56 adopts its original shape as shown in Figure 8A, which is proper for focusing distant objects.

It is important to note that the accommodation or focusing IOL 48A or 48B of the present invention functions only when enclosed by the capsular bag 20 in order to restrain the lens in its proper position. Since cataracts can be removed while leaving the capsular bag intact (extracapsular cataract extraction), the IOL 48A or 48B can be inserted into the capsular bag during implantation. This allows the ciliary body muscles to relax, increasing the aperture diameter and putting the suspensory ligaments or zonules into tension, which in turn tends to flatten the capsular bag and enhance the capability of the IOL to change its shape and refractive characteristics.

It should be noted that the drawings show the invention in exaggerated form for ease of illustration and are not drawn to scale. For example, the diameter 67 in Figure 9 is preferably about 7.5 mm, while the thickness of the membrane lens 50 in Figure 6 (i.e., dimension 63) is preferably less than 0.5 mm. Thus, a much larger difference in size exists than the drawings appear to show. Furthermore, the distance 68 in Figure 11 between the periphery 52 of the membrane lens 50 and the outer edge 71 of the lens body 54 is preferably approximately 1.5 mm, but appears to be greater in Figure 11, because the diameter of the membrane lens 50 is preferably approximately 6.0 mm.

The chamber 56 is shown in Figure 7 as having a finite thickness, indicated by dimension 90, with a suitable thickness being approximately 0.1 mm. However, it may be desirable to reduce the thickness to practically zero, in which case the membrane lens 50 would contact the base lens 54 when pressure within the chamber 56 was absent. In this instance, the membrane lens 50 would be separated from the base lens 54 by only a thin layer of fluid wetting the chamber surfaces 95 and 97 shown in Figure 8A. In either case, it is preferred that the surfaces 95 and 97 have the same radius of curvature and thus that the thickness 90 is substantially uniform.

The lens body 54 is preferably constructed of polymethylethacylate (PMMA), the membrane lens 50 and both bladders 70A and 70B are preferably constructed of a silicone elastomer, and the fluid contained within the bladders and manifolds is preferably a silicone oil. The diameters of the manifolds and channels in Figure 11 are preferably approximately 0.25 mm. The radius 99 of curvature of the surface 101 in Figure 7 is preferably approximately 16 mm, and the radius 102 of curvature of the membrane lens 50 is preferably in the range of approximately 11 mm to 16 mm, depending upon the fluid pressure applied.

Two support bladders 70A and two focusing bladders 70B are shown in Figure 11. However,

different numbers of each bladder type can be used in accordance with the invention. It is expected that satisfactory performance in accordance with the present invention can be secured with one, two, three, four, or even more support and/or accommodation bladders on the IOL. However, it is also possible to support the IOL without any support bladders 70A, but rather with conventional haptics 36, as shown in Figure 9 and discussed above.

It is possible in some circumstances, that viscous fluid forces within the manifold 85 shown in Figure 11 can retard flow and increase the time needed to fill and empty the chamber 56. Consequently, it may be desirable to spring-bias the accommodation or focusing bladders 70B by springs (as shown in Figure 13). Thus, when the pressure from the ciliary body 17 is relaxed, the springs act to expand the focusing bladder 70B, thus applying a negative pressure to the chamber 56. This negative pressure assists in overcoming the viscous fluid forces. These springs can be the coil springs 110, or the optional leaf springs 112 attached to the lens body 54, or other known types of resilient biasing devices.

It is preferred that the lens body 54 in Figure 7 is positioned posterior to the membrane lens 50 in the event that a phenomenon called posterior capsule opacification occurs. In this event, the posterior surface of the capsular bag 20, which formerly contained the crystalline lens 19 and which, after implantation, contains an IOL, becomes cloudy or opaque. A typical treatment for this condition is to remove part of the capsule, or to rupture it, using an Yttrium-Aluminum-Garnet (YAG) laser. However, the proximity of the posterior of the capsular bag to the posterior of the IOL possibly could result in the laser damaging the IOL. In the present invention, however, the lens base 54 is quite thick and thus more resistant to such damage than is the membrane lens 50.

The diameter of the membrane lens 50 should be approximately 6.0 mm, which generally is sufficient to occupy the fully dilated human iris. In this way, the pupil does not expose any of the apparatus in Figure 11, which is positioned radially outward of the periphery 52.

In order to protect against the possibility of failure of the accommodating IOL 48A or 48B, the lens is designed such that when the membrane lens 50 in Figure 7 is fully relaxed, the refractive characteristics of the lens system 48A or 48B allow the patient to view objects in a range of infinity to 6 feet (depending on pupil size and overall refractive error in the patient's eye). In this way, reduced, but acceptable, vision is still available to the patient without, or prior to, replacement of a failed lens.

Figures 14 through 24 illustrate further alternative embodiments of an intraocular lens apparatus according to the present invention. Many of the elements of the embodiments depicted in Figures 14 through 24 are generally similar, at least in terms of their function, to corresponding elements of the embodiments shown in Figure 6 through 13. Therefore, similar reference numerals have been used in Figures 14 through 24 to indicate such corresponding elements, except that the reference numerals in Figures 14 through 24 have either one-hundred or two-hundred prefixes.

Figures 14 through 19 depict various versions of an alternate embodiment of the invention, wherein IOL 148 is substantially identical to the lens apparatus shown in Figures 6 through 13, except that the accommodation bladders 70B and the support bladders 70A are replaced by one or more accommodating haptic members 170B. The accommodating haptic members 170B are constructed in the form of a generally hollow, elongated, tubular-shaped haptic member containing fluid and attached to the outer periphery of the IOL 148 in fluid communication with the fluid chamber 156.

When focusing, the muscle fibers 121 of the ciliary body contract and expand in order to forcibly deform or relax the hollow accommodating haptic members 170B, thereby forcing fluid into, or withdrawing fluid from, the chamber 156 in a manner similar to that described above in connection with Figures 9 through 13. In this way, the accommodation feature of the present invention can be advantageously combined with the supporting function of the haptic members 36 or the supporting bladders 70A described above. When the muscle fibers 121 of the ciliary body contract in a manner diagrammatically illustrated in Figure 16, the hollow accommodating haptic members 170B are compressed and may even deform into the kinked configuration shown for purposes of illustration in Figure 16. Thus, it may be found to be desirable to guard against the hollow accommodating haptic member 170B collapsing and closing off the interior chamber 190, which could cause undesirably high fluid pressures in the interior chamber 190 or the fluid-filled chamber 156 of the lens portion of the apparatus. Thus, it may be desirable to form the interior chamber 190 in a non-circular or non-cylindrical shape. Two examples of such non-circular cross-sectional shape are illustrated in Figures 18 and 19, wherein the thickness of the haptic wall 191C and 191D, respectively, is non-uniform about the hollow haptic members 170C and 170D, respectively, Such non-uniform wall thickness is created by the provision of internal discontinuities 192C and 192D, respectively, which serve to substantially prevent total closing off of the fluid flow paths in the event of collapse of all or a portion of the hollow haptic member during ciliary contraction.

In addition, since the compression, deformation or kinking of the hollow haptic members 170B must be capable of being accomplished merely be the force of ciliary muscle contraction, it also may be desirable to provided ribs or other discontinuities 193 on the

external periphery of the hollow accommodating haptic members 170B. Also, a suitable means for introducing fluid into the hollow haptic members 170B and thus the fluid-filled chamber 156B should also be provided, such as the fill port 195 shown for purposes of illustration in Figures 14 and 16.

Figures 20 through 24 illustrate still another embodiment of the present invention, wherein the IOL 248 is equipped with a fluid-filled hollow ring or conduit 270B surrounding the lens portion of the IOL 248. The circular conduit 270B functions in a manner generally similar to that described above in connection with Figures 14 through 19, and has its interior chamber 290 in fluid communication with the fluid-filled chamber 256 by way of one or more interconnecting hollow ducts 294.

As shown in Figure 21, the contraction of the muscle fibers (shown diagrammatically at reference numeral 221) causes an inwardly-directed force on the conduit 270B. This force compresses or deforms the conduit 270B to force fluid from the conduit 270B, through the interconnecting ducts 294, and into the fluid-filled chamber 256. When the muscle fibers 221 relax, the conduit 270B returns to its relatively relaxed and undeformed condition, thereby allowing the fluid pressure in the fluid-filled chamber 256 to be relieved, similar to the function described above in connection with the previously-mentioned embodiments of the present invention. Also, like the hollow accommodating haptic members 170B shown in Figures 14 through 19, the conduit 270B also serves the function of supporting the IOL 248 in the eye, and thus acts as a haptic member.

Although the interconnecting ducts 294 are shown as extending in generally radial directions and interconnected with the lens portion of the IOL 248 in a generally straight-on relationship therewith, it may be found to be desirable to form the ducts 294 in a "swept" or arcuate configuration, having a more "tangential" interconnection with the lens portion of the IOL 248, similar to that shown for purposes of illustration in Figure 22.

Also, as was mentioned above in connection with the embodiment depicted in Figures 14 through 19, the conduit 270B can be desirably equipped with ribs or other discontinuities 293 in order to facilitate the proper compression and expansion in response to ciliary body muscle movement. In this regard, it should be noted that at least a portion of the ribs or other discontinuities 293 can be in the form of a circumferentially collapsable and expandable portion of the conduit 270B, as shown in Figure 24. Such an arrangement allows the circumference of the conduit 270B to be adjustably increased or decreased in order to fit a variety of eye sizes. This is especially advantageous since the conduit 270B also serves the above-mentioned haptic function of holding and supporting the IOL 248 in the eye.

Finally, as illustrated in Figure 23, one or more interconnecting members 296, which need not be hollow, can be provided to support the conduit 270B in its spaced-apart relationship with the lens portion of the IOL 248. Such non-hollow interconnecting members 296 (if included) function merely to aid in maintaining the lens portion of the IOL 248 in its proper position after implantation in the eye.

Claims

1. An intraocular apparatus (48) for implantation in an eye, said apparatus comprising:

   a lens assembly including inner (54) and outer (50) light-transmissive lens members defining a fluid-filled chamber (56) located between said lens members, at least a portion of said outer lens (50) member being flexible; and

   accommodation means (70A,70B,75,85) for changing the shape of said chamber in response to muscle movement in the eye in order to change the overall refractive characteristics of said lens assembly, characterised in that the accommodation means includes fluid means adapted for selectively changing the fluid pressure in said fluid-filled chamber (56) in order to change the position of said outer lens member (50) relative to said inner lens member (54), and in that said fluid means includes a flexible fluid-filled bladder (70A,70B), said bladder being in fluid communication with said fluid-filled chamber (56), said bladder (70A,70B) is adapted for being in contact with muscles in the eye and is contractable and expandable in response to said eye muscle movement in order to respectively force fluid into, and withdraw fluid out of, said chamber (56) in order to cause a change in the position of said outer lens member (50) relative to said inner lens member (54) in response to said eye muscle movement.

2. An intraocular apparatus (48) adapted to be implanted in the eye, said apparatus comprising:

   a transparent and flexible outer lens membrane (50);

   a transparent and relatively rigid inner support lens member (54) located adjacent said flexible membrane (50), said flexible lens membrane (50) and said support lens member (54) being spaced apart and sealed to one another and defining a fluid chamber (56) therebetween; and

   accommodation means (70A,70B,75,85) adapted for injecting a pressurised fluid into said fluid chamber (56) between the outer lens membrane (50) and said inner support lens member (54) and for responding to eye muscle

movement in order to resiliently deform said flexible outer lens membrane (50) and thereby change the refractive characteristics of said intraocular lens apparatus.

3. An intraocular lens apparatus according to claim 2, wherein said accommodation means (70A,70B, 75,85) includes at least one fluid-filled inflatable accommodation bladder (70B) in fluid communication with said fluid chamber (56), said accommodation bladder (70B) being selectively contractable and expandable in response to eye muscle movement in order to selectively inject and withdraw said pressurised fluid into and out of said fluid chamber.

4. An intraocular lens apparatus according to claim 3, wherein said apparatus further comprises at least one flexible fluid-filled support bladder (70A), said support bladder (70A) being disposed on the outer periphery of said inner support lens member (54) and sized for contacting the ciliary body of the eye in order to support said intraocular lens apparatus in the eye.

5. An intraocular lens apparatus according to claim 4, wherein said accommodation bladder (70B) and said support bladder (70A) are separate bladders.

6. An intraocular lens apparatus according to claim 4, wherein said accommodation bladder (70B) and said support bladder (70A) are the same bladder.

7. An intraocular lens apparatus according to claim 3, wherein said apparatus further comprises at least one haptic member (36), said haptic member being disposed on the outer periphery of said inner support lens member and sized for contacting the ciliary body of the eye in order to support said intraocular lens apparatus in the eye.

8. An intraocular lens apparatus according to any preceding claim, wherein said intraocular lens apparatus is adapted for implantation in the capsular bag of the eye.

9. An intraocular lens apparatus according to claim 3, wherein said apparatus further includes resilient biasing means (110,112) for resiliently biasing said accommodation bladder (70B) toward its expanded condition.

10. An intraocular lens apparatus according to claim 9, wherein said resilient biasing means includes a spring (110) disposed within said accommodation bladder (70B).

11. An intraocular lens apparatus according to claim 9, wherein said resilient biasing means includes a spring (112) disposed between a portion of said support lens and said accommodation bladder (70B).

12. An intraocular apparatus (48) for implantation in an eye, said apparatus comprising:

a lens assembly including inner (54) and outer (50) light-transmissive lens members defining a fluid-filled chamber (56) located between said lens members, at least a portion of said outer lens (50) member being flexible; and

accommodation means (70A,70B,75,85) for changing the shape of said chamber (156) in response to muscle movement in the eye in order to change the overall refractive characteristics of said lens assembly, characterised in that said accommodation means (70A,70B,75,85) includes fluid means for selectively changing the fluid pressure in said fluid-filled chamber (156) in order to change the position of said outer lens member (50) relative to said inner lens member (54), said fluid means further including at least one elongated hollow and generally tubular-shaped haptic member (170B) interconnected with said inner and outer lens members, said hollow haptic member (170B) including an external peripheral surface thereon and an interior wall defining an interior volume, said interior volume having said fluid therein and being in fluid communication with said fluid-filled chamber (156), at least a portion of said hollow haptic member (170B) being contractable and expandable in response to said eye muscle movement in order to respectively force fluid into, and withdraw fluid out of, said fluid-filled chamber (156) in order to cause a change in the position of said outer lens member (50) relative to said inner lens member (54) in response to said eye muscle movement.

13. An intraocular lens apparatus according to claim 12,wherein said hollow haptic member (170B) has external discontinuities (193) on said external peripheral surface, said discontinuities tending to facilitate said contraction and expansion in response to said eye muscle movement.

14. An intraocular lens apparatus according to claim 13, wherein said discontinuities (193) include ribs extending around at least a portion of said external peripheral surface.

15. An intraocular lens apparatus according to claim 12, 13 or 14, wherein said hollow haptic member (170B) has a non-circular hollow internal cross-

sectional shape (190C,190D) in order to substantially prevent complete collapse of said hollow haptic member (170B) during said contraction.

16. An intraocular lens apparatus according to claim 15, wherein said internal cross-sectional shape of said hollow haptic member includes at least one inwardly-protruding portion (192C) on said interior wall.

17. An intraocular lens apparatus according to claim 15, wherein the lateral distance between said external peripheral surface and said interior wall being non-uniform around said hollow haptic member (170B).

18. An intraocular apparatus (248) for implantation in an eye, said apparatus comprising:

a lens assembly including inner (54) and outer (50) light-transmissive lens members defining a fluid-filled chamber (156,256) located between said lens members, at least a portion of said outer lens (50) member being flexible; and

accommodation means for changing the shape of said chamber in response to muscle movement in the eye in order to change the overall refractive characteristics of said lens assembly, characterised in that said accommodation means includes fluid means for selectively changing the fluid pressure in said fluid-filled chamber (156,256) in order to change the position of said outer lens member (50) relative to said inner lens member (54), said fluid means further including an elongated generally circular hollow conduit (270B) extending circumferentially around the periphery of said inner and outer lens members, said hollow conduit (270B) including an external peripheral surface thereon and an interior wall defining an interior volume (290) of said hollow conduit, said interior volume (290) having said fluid therein and being in fluid communication with said fluid-filled chamber (156,256), at least a portion of said hollow conduit being contractable and expandable in order to respectively force fluid into, and withdraw fluid out of, said fluid-filled chamber in order to cause a change in the position of said outer lens member (50) relative to said inner lens member (54) in response to said eye muscle movement.

19. An intraocular lens apparatus according to claim 18, wherein said hollow conduit (270B) has external discontinuities (293) on said external peripheral surface, said discontinuities (293) tending to facilitate said contraction and expansion in response to said eye muscle movement.

20. An intraocular lens apparatus according to claim 19, wherein said discontinuities (293) include ribs extending around at least a portion of said external peripheral surface.

21. An intraocular lens apparatus according to claim 18, wherein at least a portion of said hollow conduit (270B) is spaced apart from said periphery of said inner and outer lens members, said interior volume (290) being interconnected with said fluid-filled chamber by one or more interconnecting hollow ducts (294) extending between said hollow conduit (270B) and said inner (50) and outer (54) lens members.

22. An intraocular lens apparatus according to claim 21, wherein said hollow duct (294) extends generally radially between said hollow conduit (220B) and said inner (50) and outer (54) lens members.

23. An intraocular lens apparatus according to claim 21, wherein said hollow duct (294) extends along a generally arcuate path between said hollow conduit (270B) and said inner (50) and outer (54) lens members.

24. An intraocular lens apparatus according to claim 21, wherein a portion of said hollow conduit (270B) is selectively expandable and contractable circumferentially at least prior to said implantation in the eye in order to allow said apparatus to be sized to fit a number of different eye sizes.

Patentansprüche

1. Intraokulare Vorrichtung (48) für die Implantation in ein Auge, umfassend:

ein Linsenanordnung, die innere (54) und äußere (50) lichtleitende Linsenelemente enthält, welche eine mit Flüssigkeit gefüllte Kammer (56) definieren, die zwischen den Linsenelementen angeordnet ist, wobei mindestens ein Teil des äußeren Linsenelements (50) flexibel ist; und

Akkommodationsvorrichtungen (70A, 70B, 75, 85) zum Verändern der Form dieser Kammer als Reaktion auf eine Muskelbewegung im Auge und zum Verändern der gesamten Lichtbrechungseigenschaften der Linsenanordnung, dadurch gekennzeichnet, daß die Akkommodationsvorrichtung eine Flüssigkeitseinrichtung enthält, die zur selektiven Änderung des Flüssigkeitsdrucks in der mit Flüssigkeit gefüllten Kammer (56) ausgebildet ist, um die Position des äußeren Linsenelements (50) bezüglich des inneren Linsenelements (54) zu verändern, und daß diese Flüssigkeit eine flexible, mit Flüssigkeit

gefüllte Blase (70A, 70B) enthält, welche über die Flüssigkeit in Verbindung mit der mit Flüssigkeit gefüllten Kammer (56) steht, wobei die Blase (70A, 70B) für einen Kontakt mit den Augenmuskeln ausgebildet und als Reaktion auf die Bewegung der Augenmuskeln kontrahierbar und expandierbar ist, um jeweils Flüssigkeit in die Kammer (56) zu hineinzupressen oder aus ihr abzuziehen, um so eine Änderung der Position des äußeren Linsenelements (50) relativ zu dem inneren Linsenelement (54) als Reaktion auf die Bewegung des Augenmuskels zu bewirken.

2. Intraokulare Vorrichtung (48), die zum Einpflanzen in das Auge ausgebildet ist, umfassend:

eine transparente und flexible äußere Linsenmembran (50);

eine transparente und relative starre innere Stützlinse (54), die sich gegenüber der flexiblen Membran (50) befindet, wobei die flexible Linsenmembran (50) und die Stützlinse (54) voneinander in Abstand gehalten und miteinander versiegelt sind, und so die dazwischenliegende Flüssigkeitskammer (56) definieren; und

eine Akkommodationsvorrichtung (70A, 70B, 75, 85), die zum Einspritzen einer unter Druck stehenden Flüssigkeit in die Flüssigkeitskammer (56) zwischen der äußeren Linsenmembran (50) und dem inneren Stützlinsenelement (54) und zum Reagieren auf die Bewegung des Augenmuskels ausgebildet ist, um die flexible äußere Linsenmembran (50) elastisch zu deformieren und dadurch die Lichtbrechungseigenschaften der intraokularen Linsenvorrichtung zu verändern.

3. Intraokular Linsenvorrichtung nach Anspruch 2, worin die Akkommodationsvorrichtung (70A, 70B, 75, 85) mindestens eine mit Flüssigkeit gefüllte aufblasbare Akkommodationsblase (70B) enthält, die über die Flüssigkeit mit der Flüssigkeitskammer (56) in Verbindung steht, wobei die Akkommodationsblase (70B) auf die Bewegung des Augenmuskels selektiv mit Kontraktion und Expansion reagiert, um die unter Druck stehende Flüssigkeit selektiv in die Flüssigkeitskammer zu einzuspritzen und diese aus ihr abzuziehen.

4. Intraokulare Linsenvorrichtung nach Anspruch 3, worin die Vorrichtung darüber hinaus mindestens eine flexible, mit Flüssigkeit gefüllte Stützblase (70A) umfaßt, die auf der äußeren Peripherie der inneren Stützlinse (54) angeordnet ist und deren Größe so bemessen ist, daß sie den Ziliarkörper des Auges berührt, um die intraokulare Linsenvorrichtung im Auge zu stützen.

5. Intraokulare Linsenvorrichtung nach Anspruch 4, worin die Akkommodationsblase (70B) und die Stützblase (70A) separate Blasen sind.

6. Intraokulare Linsenvorrichtung nach Anspruch 4, worin die Akkomodationsblase (70B) und die Stützblase (70B) dieselbe Blase sind.

7. Intraokulare Linsenvorrichtung nach Anspruch 3, worin die Vorrichtung darüber hinaus mindestens ein haptisches Element (36) umfaßt, und wobei das haptische Element an der äußeren Peripherie der inneren Stützlinse angebracht ist und dessen Größe so bemessen ist, daß es den Ziliarkörper des Auges berührt, um die intraokulare Linsenvorrichtung im Auge zu stützen.

8. Intraokulare Linsenvorrichtung nach einem der vorhergehenden Ansprüche, worin die intraokulare Linsenvorrichtung zur Implantation in den Kapselbeutel des Auges ausgebildet ist.

9. Intraokulare Linsenvorrichtung nach Anspruch 3, worin die Vorrichtung darüber hinaus elastische Vorspannvorrichtungen (110, 112) zum elastischen Vorspannen der Akkommodationsblase (170) in Richtung des expandierten Zustandes, enthält.

10. Intraokulare Linsenvorrichtung nach Anspruch 9, worin die elastische Vorspannvorrichtung eine Feder (110) umfaßt, die innerhalb der Akkommodationsblase (70B) angeordnet ist.

11. Intraokulare Linsenvorrichtung nach Anspruch 9, worin die elastische Vorspannvorrichtung eine Feder (112) umfaßt, die zwischen einem Teil der Stützlinse und der Akkommodationsblase (70B) angeordnet ist.

12. Intraokulare Vorrichtung (48) für die Implantation in ein Auge, umfassend:

eine Linsenanordnung, die innere (54) und äußere (50) lichtleitend Linsenelemente enthält, die eine zwischen diesen Linsenelementen angeordnete mit Flüssigkeit gefüllte Kammer (56) definieren, wobei mindestens ein Teil des äußeren Linsenelements (50) flexibel ist und

Akkommodationsvorrichtungen (70A, 70B, 75, 85), um die Form der Kammer (156) als Reaktion auf die Muskelbewegung des Auges zu verändern, und um so die gesamten Lichtbrechungseigenschaften der Linsenanordnung zu ändern, dadurch gekennzeichnet, daß die Akkommodationsvorrichtungen (70A, 70B, 75, 85) eine Flüssigkeitseinrichtung zur selektiven Änderung des Flüssigkeitsdrucks in der mit Flüssigkeit gefüllten Kammer (156) enthalten, um die Position des äußeren Linsenelements (50) relativ zu

dem inneren Linsenelement (54) zu verändern, wobei die Flüssigkeitseinrichtung weiterhin mindestens ein verlängertes hohles und im allgemeinen röhrenförmiges haptisches Element (170B) einschließt, das mit den inneren und äußeren Linsenelementen verbunden ist, wobei das hohle haptische Element (170B) eine äußere periphere Oberfläche und eine innere Wand aufweist, die ein inneres Volumen definieren, und wobei sich diese Flüssigkeit in diesem inneren Volumen befindet, welches über diese Flüssigkeit in Verbindung mit der mit Flussigkeit gefüllten Kammer (156) steht, wobei mindestens ein Teil des hohlen haptischen Elements (170B) als Reaktion auf die Bewegung des Augenmuskels kontrahierbar und expandierbar ist, um Flüssigkeit in die mit Flüssigkeit gefüllte Kammer (156) hineinzupressen und Flüssigkeit aus
dieser abzuziehen, um eine Änderung der Position des äußeren Linsenelements (50) relativ zum inneren Linsenelement (54) als Reaktion auf die Bewegung des Augenmuskels zu bewirken.

13. Intraokulare Linsenvorrichtung nach Anspruch 12, worin das hohle haptische Element (170B) äußere Diskontinuitäten (193) auf der äußeren peripheren Oberfläche aufweist, die dazu führen, die Kontraktion und Expansion als Reaktion auf die Bewegung des Augenmuskels zu erleichtern.

14. Intraokulare Linsenvorrichtung nach Anspruch 13, worin die Diskontinuitäten (193) Rippen aufweisen, die sich mindestens über einen Teil der äußeren peripheren Oberfläche erstrecken.

15. Intraokulare Linsenvorrichtung nach Anspruch 12, 13 oder 14, worin das hohle haptische Element (170B) eine nichtzirkulare, hohle innere Queschnittsform (190C, 190D) aufweist, um weitgehend den völligen Zusammenbruch des hohlen haptischen Elements (170B) während der Kontraktion zu verhindern.

16. Intraokulare Linsenvorrichtung nach Anspruch 15, worin die innere Querschnittsform des hohlen haptischen Elements mindestens einen innen überstehenden Teil (192C) auf der inneren Wand aufweist.

17. Intraokulare Linsenvorrichtung nach Anspruch 15, worin der Seitenabstand zwischen der äußeren peripheren Oberfläche und der inneren Wand rund um das hohle haptische Element (170B) ungleichförmig ist.

18. Intraokulare Vorrichtung (248) für die Implantation in ein Auge, umfassend:

eine Linsenanordnung, die innere (54) und äußere (50) lichtleitende Linsenelemente enthält, welche eine mit Flüssigkeit gefüllte Kammer (156, 256) definieren, die zwischen den Linsenelementen angeordnet ist, wobei mindestens ein Teil des äußeren Linsenelements (50) flexibel ist; und

Akkommodationsvorrichtungen, um die Form der Kammer als Reaktion auf eine Muskelbewegung im Auge und die gesamten Lichtbrechungseigenschaften der Linsenanordnung zu verändern, dadurch gekennzeichnet, daß die Akkommodationsvorrichtung eine Flüssigkeitseinrichtung zur selektiven Änderung des Flüssigkeitsdrucks in der mit Flüssigkeit gefüllten Kammer (156, 256) aufweist, um die Position des äußeren Linsenelements (50) bezüglich des inneren Linsenelements (54) zu verändern, wobei die Flüssigkeitseinrichtung weiterhin eine verlängerte, im allgemeinen kreisförmige hohle Leitung (270B) enthält, die sich über den peripheren Umfang der inneren und äußeren Linsenelemente erstreckt, wobei die hohle Leitung (270B) eine darauf befindliche äußere periphere Oberfläche und eine innere Wand aufweist, die ein inneres Volumen (290) der hohlen Leitung definiert, wobei das innere Volumen (290) die Flüssgkeit enthält und über diese mit der mit Flüssigkeit gefüllten Kammer (156, 256) in Verbindung steht, mindestens ein Teil der hohlen Leitung kontrahierbar und expandierbar ist, um Flüssigkeit in die mit Flüssigkeit gefüllte Kammer hineinzupressen und aus dieser abzuziehen, um eine Änderung der Position der äußeren Linsenelemente (50) relativ zum inneren Linsenelement (54) als Reaktion auf die Bewegung des Augenmuskels zu bewirken.

19. Intraokulare Linsenvorrichtung nach Anspruch 18, worin die hohle Leitung (270B) äußere Diskontinuitäten (293) auf der äußeren peripheren Oberfläche aufweist, die dazu führen, die Kontraktion und Expansion als Reaktion auf die Bewegung des Augenmuskels zu erleichtern.

20. Intraokulare Linsenvorrichtung nach Anspruch 19, worin die Diskontinuitäten (293) Rippen aufweisen, die sich über mindestens einen Teil der äußeren peripheren Oberfläche erstrecken.

21. Intraokulare Linsenvorrichtung nach Anspruch 18, worin mindestens ein Teil der hohlen Leitung (270B) von der Peripherie der inneren und äußeren Linsenelemente in Abstand gehalten ist, wobei das innere Volumen (290) mit der mit Flüssigkeit gefüllten Kammer über eine oder mehrere verbindende hohle Röhren (294), die sich zwischen der hohlen Leitung (270B) und den inneren (50) und äußeren (54) Linsenelementen erstrecken, verbunden ist.

22. Intraokulare Linsenvorrichtung nach Anspruch 21, worin sich die hohle Röhre (294) im allgemeinen strahlenförmig zwischen der hohlen Leitung (220B) und den inneren (50) und äußeren (54) Linsenelementen erstreckt.

23. Intraokulare Linsenvorrichtung nach Anspruch 21, worin sich die hohle Röhre (294) entlang eines im allgemeinen gebogenen Pfads zwischen der hohlen Leitung (270B) und den inneren (50) und äußeren (54) Linsenelementen erstreckt.

24. Intraokulare Linsenvorrichtung nach Anspruch 21, worin ein Teil der hohlen Leitung (270B) zumindest vor der Implantation in das Auge im Umfang selektiv expandierbar und kontrahierbar ist, um an der Vorrichtung eine Größeneinstellung vornehmen zu können, damit sie für verschiedene Augengrößen paßt.

Revendications

1. Dispositif intra-oculaire (48) pour implantation dans un oeil, ledit dispositif comprenant:
   - un ensemble de lentilles comprenant des lentilles intérieure (54) et extérieure (50) transmettant la lumière et définissant une chambre (56) remplie de fluide, et située entre lesdites lentilles, au moins une partie de ladite lentille extérieure (50) étant flexible; et
   - un moyen (70A, 70B, 75, 85) d'accommodation pour changer la forme de ladite chambre en réponse à un mouvement des muscles dans l'oeil, afin de changer les caractéristiques globales de réfraction dudit ensemble de lentilles, caractérisé en ce que le moyen d'accommodation comprend un moyen de fluide adapté pour changer de façon sélective la pression de fluide dans ladite chambre (56) remplie de fluide, afin de changer la position de ladite lentille extérieure (50) par rapport à ladite lentille intérieure (54), et en ce que ledit moyen de fluide comprend une vessie flexible (70A, 70B) remplie de fluide, ladite vessie étant en communication de fluide avec ladite chambre (56) remplie de fluide, ladite vessie (70A, 70B) étant adaptée pour être en contact avec les muscles de l'oeil, et étant contractable et expansible en réponse auxdits mouvements des muscles de l'oeil afin, respectivement, de forcer le fluide à l'intérieur de ladite chambre (56) et de soutirer le fluide hors de cette dernière, dans le but de provoquer un changement dans la position de ladite lentille extérieure (50) par rapport à ladite lentille intérieure (54), en réponse auxdits mouvements des muscles de l'oeil.

2. Dispositif intra-oculaire (48) adapté pour être implanté dans l'oeil, ledit dispositif comprenant:
   - une membrane (50) de lentille extérieure, transparente et flexible;
   - une lentille support intérieure (54), transparente et relativement rigide, située de façon adjacente à ladite membrane flexible (50), ladite membrane flexible (50) de lentille et ladite lentille support (54) étant espacées l'une de l'autre et scellées l'une à l'autre et définissant une chambre (56) de fluide entre elles; et
   - un moyen (70A, 70B, 75, 85) d'accommodation adapté pour injecter un fluide pressurisé dans ladite chambre (56) de fluide entre la membrane (50) de lentille extérieure et ladite lentille support intérieure (54), et pour répondre aux mouvements des muscles de l'oeil, dans le but de déformer de façon élastique ladite membrane flexible (50) de lentille extérieure, et changer ainsi les caractéristiques de réfraction dudit dispositif de lentilles intra-oculaires.

3. Dispositif de lentilles intra-oculaires selon la revendication 2, dans lequel le moyen (70A, 70B, 75, 85) comprend au moins une vessie (70B) d'accommodation gonflable et remplie de fluide, en communication de fluide avec ladite chambre (56) de fluide, ladite vessie (70B) d'accommodation étant, de façon sélective, contractable et extensible en réponse aux mouvements des muscles de l'oeil, afin, de façon sélective, d'injecter ledit fluide pressurisé à l'intérieur de ladite chambre de fluide et de le soutirer hors de cette dernière.

4. Dispositif de lentilles intra-oculaires selon la revendication 3, dans lequel ledit dispositif comprend de plus au moins une vessie support flexible (70A) remplie de fluide, ladite vessie support (70A) étant disposée sur la périphérie extérieure de ladite lentille support intérieure (54), et dimensionnée pour être en contact avec le corps ciliaire de l'oeil, afin de supporter ledit dispositif de lentilles intra-oculaires dans l'oeil.

5. Dispositif de lentilles intra-oculaires selon la revendication 4, dans lequel ladite vessie (70B) d'accommodation et ladite vessie support (70A) sont des vessies séparées.

6. Dispositif de lentilles intra-oculaires selon la revendication 4, dans lequel ladite vessie (70B) d'accommodation et ladite vessie support (70A) sont la même vessie.

7. Dispositif de lentilles intra-oculaires selon la revendication 3, dans lequel ledit dispositif comprend de plus au moins un élément haptique (36), ledit élément haptique étant disposé sur la périphérie extérieure de la lentille support intérieure, et dimensionné pour être en contact avec le corps ciliaire de l'oeil, afin de supporter ledit dispositif de lentilles intra-oculaires dans l'oeil.

8. Dispositif de lentilles intra-oculaires selon l'une quelconque des revendications précédentes, dans lequel ledit dispositif de lentilles intra-oculaires est adapté pour son implantation dans le sac capsulaire de l'oeil.

9. Dispositif de lentilles intra-oculaires selon la revendication 3, dans lequel ledit dispositif comprend de plus un moyen élastique (110, 112) de déviation, pour dévier de façon élastique ladite vessie (70B) d'accommodation vers sa condition expansée.

10. Dispositif de lentilles intra-oculaires selon la revendication 9, dans lequel ledit moyen élastique de déviation comporte un ressort (110) disposé à l'intérieur de ladite vessie (70B) d'accommodation.

11. Dispositif de lentilles intra-oculaires selon la revendication 9, dans lequel ledit moyen élastique de déviation comporte un ressort (112) disposé entre une partie de ladite lentille support et ladite vessie (70B) d'accommodation.

12. Dispositif intra-oculaire (48) pour implantation dans un oeil, ledit dispositif comprenant:
- un ensemble de lentilles comprenant des lentilles intérieure (54) et extérieure (50) transmettant la lumière et définissant une chambre (56) remplie de fluide, et située entre lesdites lentilles, au moins une partie de ladite lentille extérieure (50) étant flexible; et
- un moyen (70A, 70B, 75, 85) d'accommodation pour changer la forme de ladite chambre (156) en réponse à un mouvement des muscles dans l'oeil, afin de changer les caractéristiques globales de réfraction dudit ensemble de lentilles, caractérisé en ce que ledit moyen d'accommodation (70A, 70B, 75, 85) comprend un moyen de fluide pour changer de façon sélective la pression de fluide dans ladite chambre (156) remplie de fluide, afin de changer la position de ladite lentille extérieure (50) par rapport à ladite lentille intérieure (54), ledit moyen de fluide comprenant de plus au moins un élément haptique (170B) allongé creux et généralement de forme tubulaire, interconnecté avec lesdites lentilles intérieure et extérieure, ledit élément haptique creux (170B) comprenant une surface périphérique extérieure sur lui-même et une paroi intérieure définissant un volume intérieur, ledit volume intérieur contenant ledit fluide en lui-même et étant en communication de fluide avec ladite chambre (156) remplie de fluide, au moins une partie dudit élément haptique creux (170B) étant contractable et expansible en réponse auxdits mouvements des muscles de l'oeil, afin, respectivement, de forcer le fluide à l'intérieur de ladite chambre (156) remplie de fluide et de soutirer le fluide hors de cette dernière, dans le but de provoquer un changement dans la position de ladite lentille extérieure (50) par rapport à ladite lentille intérieure (54), en réponse auxdits mouvements des muscles de l'oeil.

13. Dispositif de lentilles intra-oculaires selon la revendication 12, dans lequel ledit élément haptique creux (170B) a des discontinuités externes (193) sur ladite surface périphérique externe, lesdites discontinuités tendant à faciliter lesdites contraction et expansion, en réponse auxdits mouvements des muscles de l'oeil.

14. Dispositif de lentilles intra-oculaires selon la revendication 13, dans lequel lesdites discontinuités comportent des nervures s'étendant à l'entour au moins sur une partie de ladite surface périphérique externe.

15. Dispositif de lentilles intra-oculaires selon les revendications 12, 13 ou 14, dans lequel ledit élément haptique creux (170B) a une forme (190C, 190D) de section transversale interne creuse non circulaire, afin de prévenir de façon substantielle un complet dégonflement dudit élément haptique creux (170B) durant ladite contraction.

16. Dispositif de lentilles intra-oculaires selon la revendication 15, dans lequel ladite forme de section transversale interne dudit élément haptique creux comprend au moins une partie (192C) faisant saillie vers l'intérieur sur ladite paroi intérieure.

17. Dispositif de lentilles intra-oculaires selon la revendication 15, dans lequel la distance latérale entre ladite surface périphérique extérieure et ladite paroi intérieure est non-uniforme autour dudit élément haptique creux (170B).

18. Dispositif intra-oculaire (248) pour implantation

dans un oeil, ledit dispositif comprenant:

– un ensemble de lentilles comprenant des lentilles intérieure (54) et extérieure (50) transmettant la lumière et définissant une chambre (156, 256) remplie de fluide et située entre lesdites lentilles, au moins une partie de ladite lentille extérieure (50) étant flexible; et

– un moyen d'accommodation pour changer la forme de ladite chambre en réponse à un mouvement des muscles dans l'oeil, afin de changer les caractéristiques globales de réfraction dudit ensemble de lentilles, caractérisé en ce que ledit moyen d'accommodation comprend un moyen de fluide pour changer de façon sélective la pression de fluide dans ladite chambre (156, 256) remplie de fluide, afin de changer la position de ladite lentille extérieure (50) par rapport à ladite lentille intérieure (54), ledit moyen de fluide comprenant de plus un conduit creux allongé (270B) généralement circulaire, s'étendant de façon circonférentielle autour de la périphérie desdites lentilles intérieure et extérieure, ledit conduit creux (270B) comprenant une surface périphérique extérieure sur lui-même et une paroi intérieure définissant un volume intérieur (290) dudit conduit creux, ledit volume intérieur (290) contenant ledit fluide en lui-même et étant en communication de fluide avec ladite chambre (156, 256) remplie de fluide, au moins une partie dudit conduit creux étant contractable et expansible, afin, respectivement, de forcer le fluide à l'intérieur de ladite chambre remplie de fluide, et de soutirer le fluide hors de cette dernière, dans le but de provoquer un changement dans la position de ladite lentille extérieure (50) par rapport à ladite lentille intérieure (54), en réponse auxdits mouvements des muscles de l'oeil.

19. Dispositif de lentilles intra-oculaires selon la revendication 18, dans lequel ledit conduit creux (270B) a des discontinuités externes (293) sur ladite surface périphérique externe, lesdites discontinuités (293) tendant à faciliter lesdites contraction et expansion en réponse auxdits mouvements des muscles de l'oeil.

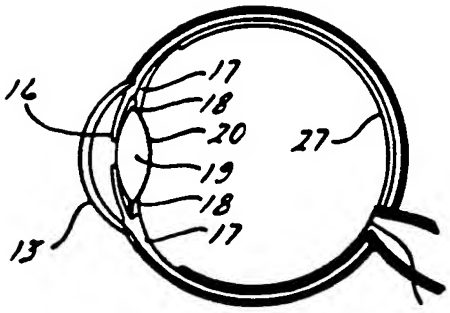
20. Dispositif de lentilles intra-oculaires selon la revendication 19, dans lequel lesdites discontinuités (293) comportent des nervures s'étendant à l'entour au moins sur une partie de ladite surface périphérique.

21. Dispositif de lentilles intra-oculaires selon la revendication 18, dans lequel au moins une partie dudit conduit creux (270B) est espacé de ladite périphérie desdites lentilles intérieure et extérieure, ledit volume intérieur (290) étant interconnecté avec ladite chambre remplie de fluide par un ou plusieurs conduits creux (294) d'interconnexion s'étendant entre ledit conduit creux (270B) et lesdites lentilles intérieure (50) et extérieure (54).

22. Dispositif de lentilles intra-oculaires selon la revendication 21, dans lequel ledit conduit creux (294) s'étend généralement radialement entre ledit conduit creux (220B) et lesdites lentilles intérieure (50) et extérieure (54).

23. Dispositif de lentilles intra-oculaires selon la revendication 21, dans lequel ledit conduit creux (294) s'étend le long d'un chemin généralement arqué entre ledit conduit creux (270B) et lesdites lentilles intérieure (50) et extérieure (54).

24. Dispositif de lentilles intra-oculaires selon la revendication 21, dans lequel une partie dudit conduit creux (270B) est, sélectivement, expansible et contractable de façon circonférentielle, au moins avant ladite implantation dans l'oeil, afin de permettre de dimensionner ledit dispositif, pour convenir à un certain nombre de différentes tailles d'yeux.



Prior Art

FIG. 1.

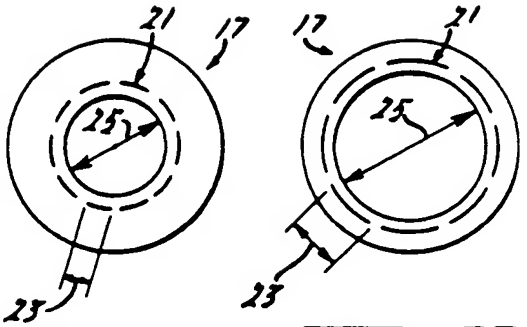


FIG. 2A. FIG. 2B.

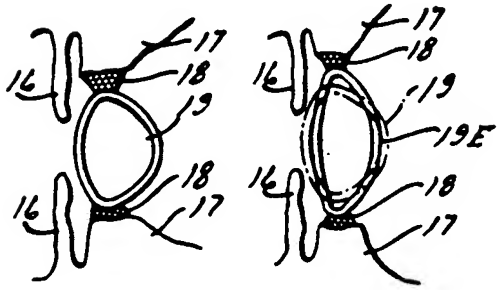
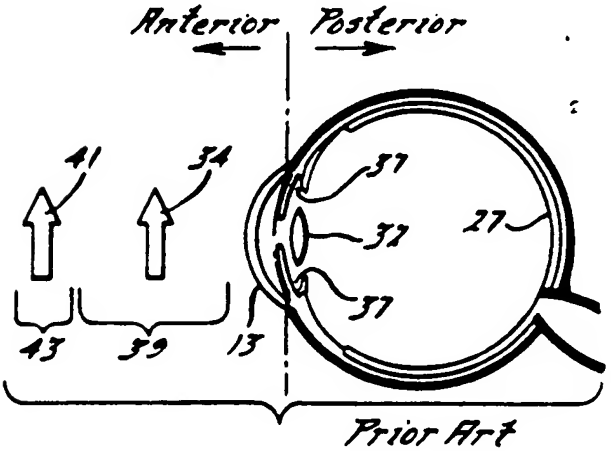
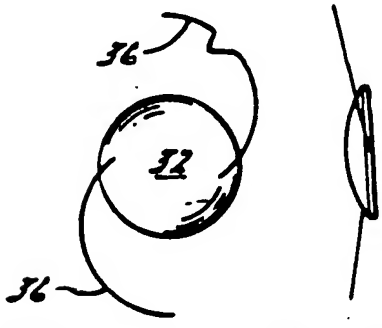


FIG. 3A. FIG. 3B.



Prior Art

FIG. 4.



Prior Art

FIG. 5A.

Prior Art

FIG. 5B.

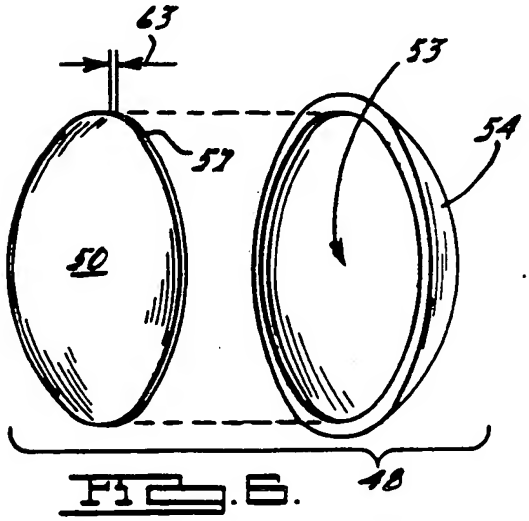


FIG. 6.

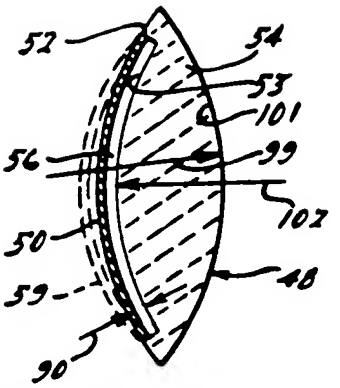


FIG. 7.

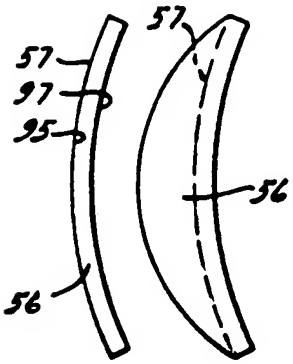


FIG. 8A.

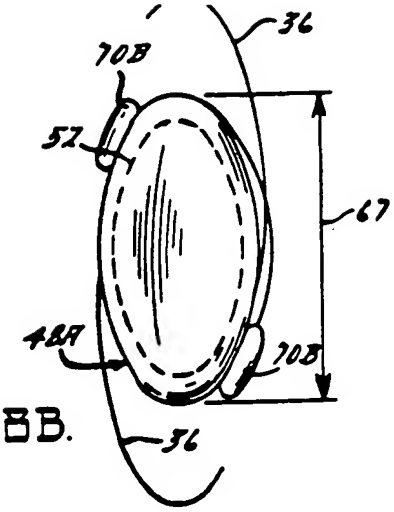


FIG. 8B.

FIG. 9.

FIG. 10.

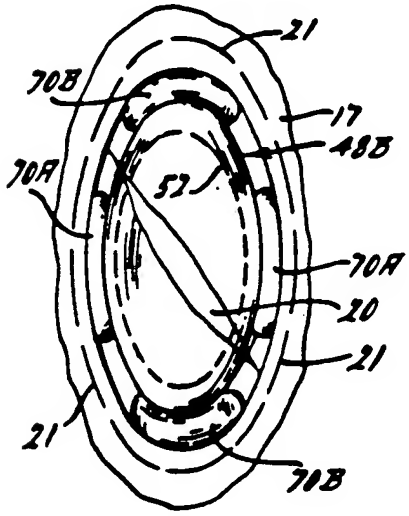
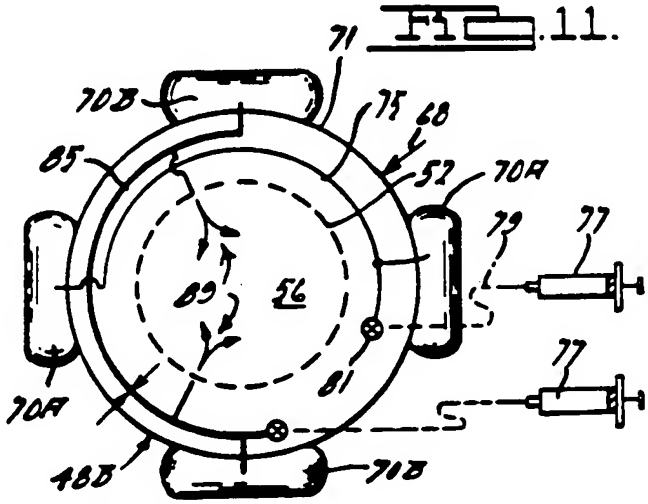


FIG. 11.



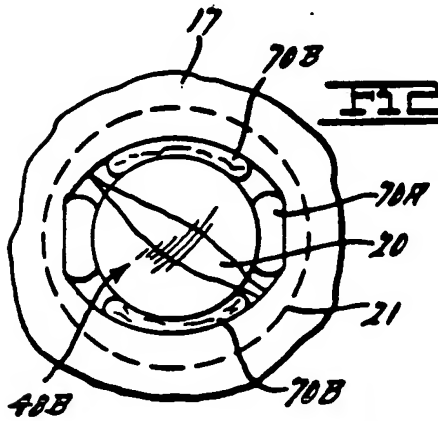


FIG. 12.

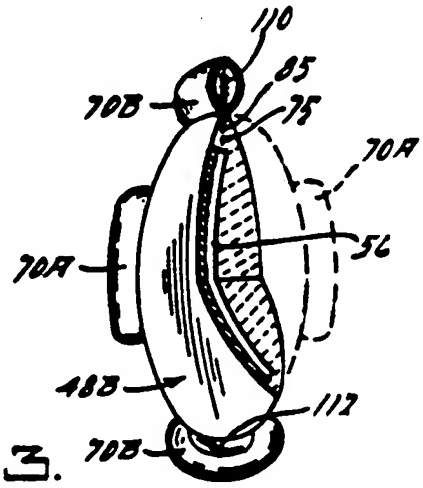


FIG. 13.

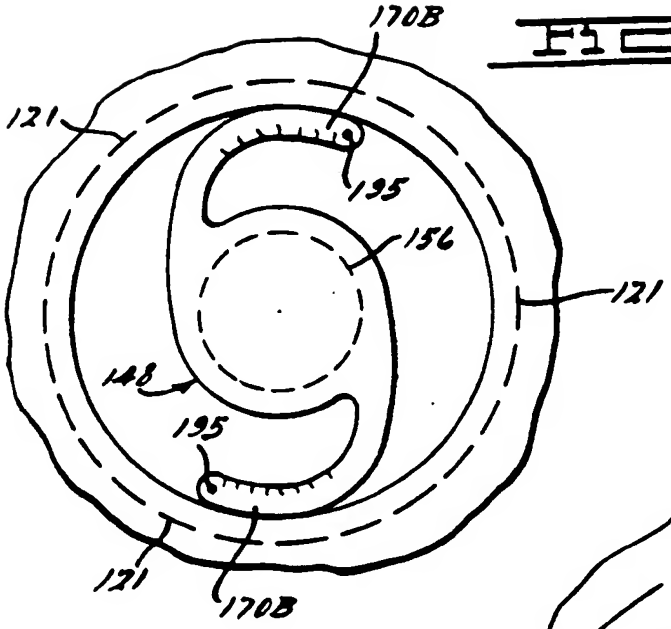


FIG. 14.

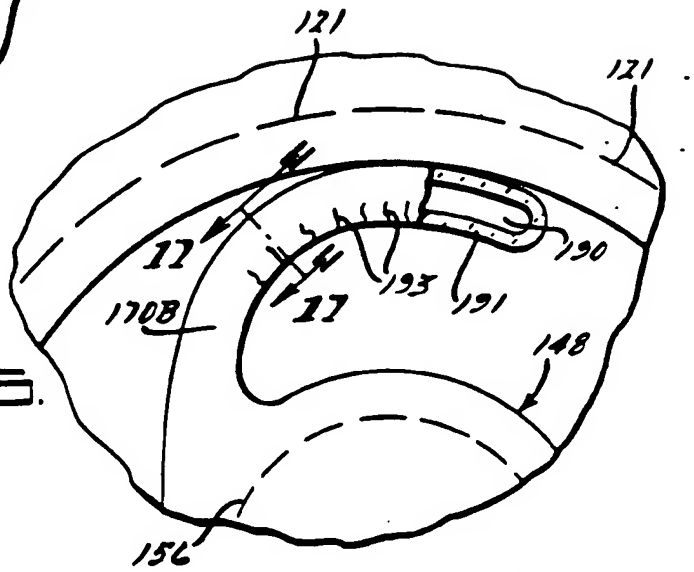
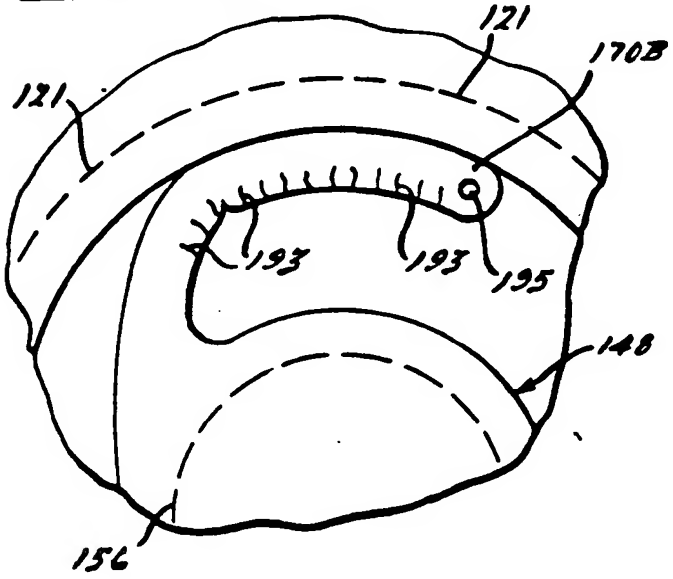


FIG. 15.

FIG. 16.



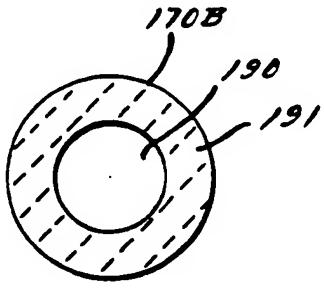


FIG. 17.

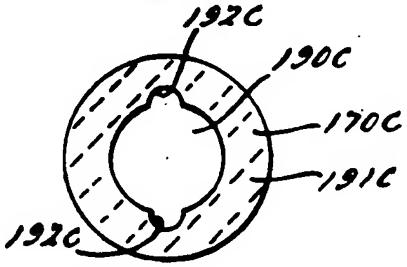


FIG. 18.

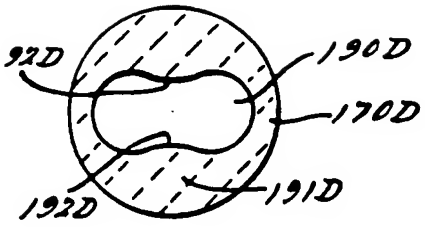


FIG. 19.

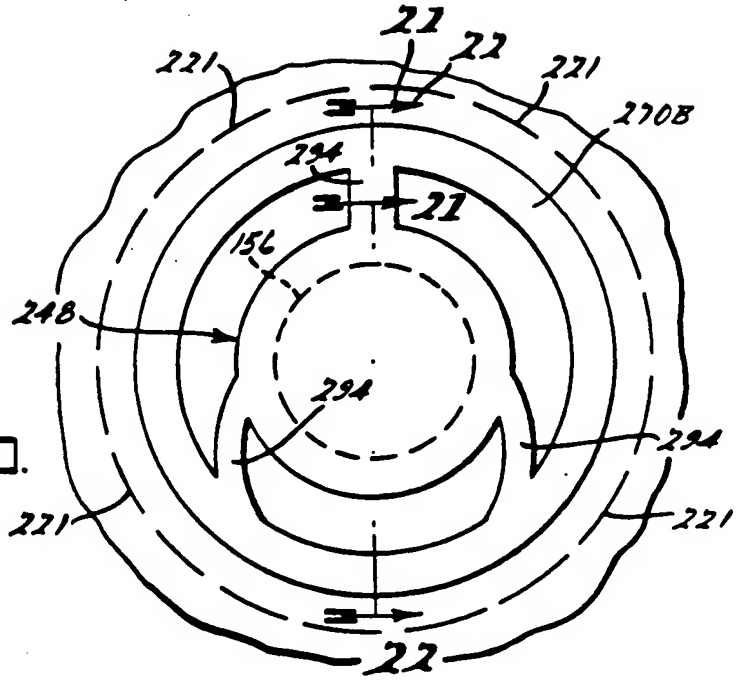
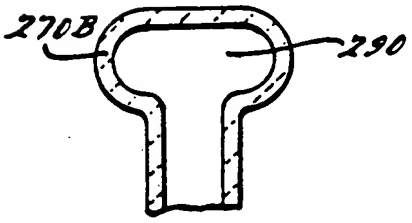


FIG. 20.

FIG. 21.



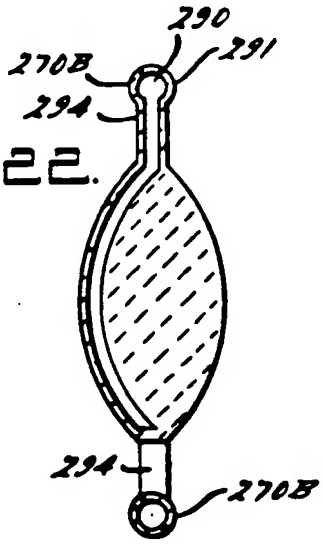


FIG. 22.

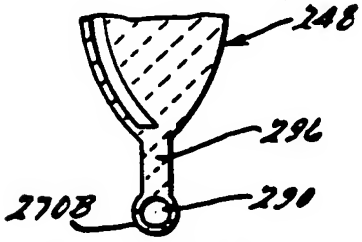


FIG. 23.

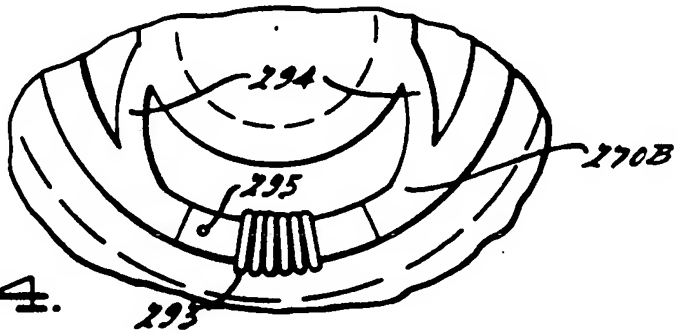


FIG. 24.